INTERIM REPORT

(Monthly Prog. Rpt. No. 9)

Feb 1967

Contract NAS 9-5872

National Aeronautics and Space Administration

LUNAR SAMPLE RECEIVING LABORATORY GLOVE SYSTEM

N67 23327

INTERIM REPORT

(Monthly Progress Report No. 9)

February 1967

Contract NAS 9-5872

SPACE SCIENCES LABORATORIES
LITTON SYSTEMS, INC.
Beverly Hills, California

ABSTRACT

This interim report covers the four-month period from October, 1966 until January, 1967, during which time the Space Sciences Laboratories of Litton Systems, Inc. have fulfilled Phase B of the program. Phase B was primarily concerned with 4 areas of investigation:

1. Development of prototype one-atmosphere glove.
2. Final design and fabrication of all components for a prototype one-atmosphere arm.
3. Development of a differentially-pumped overglove system.
4. Initiate quality assurance procedures.

The performance and completion of these tasks is described. Test data are included in Appendix A.

INTRODUCTION

Under the terms of Contract NAS 9-5872, Litton undertook to develop a one-atmosphere glove system with a very low leak rate capable of performing in vacuum chambers maintained at a pressure of 10^{-6} Torr.

Phase A of the program was completed in September, 1966 and concerned itself with determining the optimum configuration of all components.

This report describes the work performed in Phase B of the work schedule in which the design and fabrication of two prototype, one-atmosphere arm systems was completed. The system comprised a pair of operational arms and a pair of overgloves. An additional task of the program was to initiate quality assurance documentation. The recommended revised work schedule is reproduced for reference in Figure 1.

The completed arms were demonstrated to NASA personnel at the Phase B design review held at Litton on January 30, 1967.

The overgloves were only partially completed at the design review meeting; however, they are expected to be finished, tested, and shipped at or near the same time as the prototype arms.

The work gloves, made of knit stainless steel fabric, are not part of the prototype system; however, they will be furnished with the final system.

The following paragraphs describe the work performed during Phase B of the program.

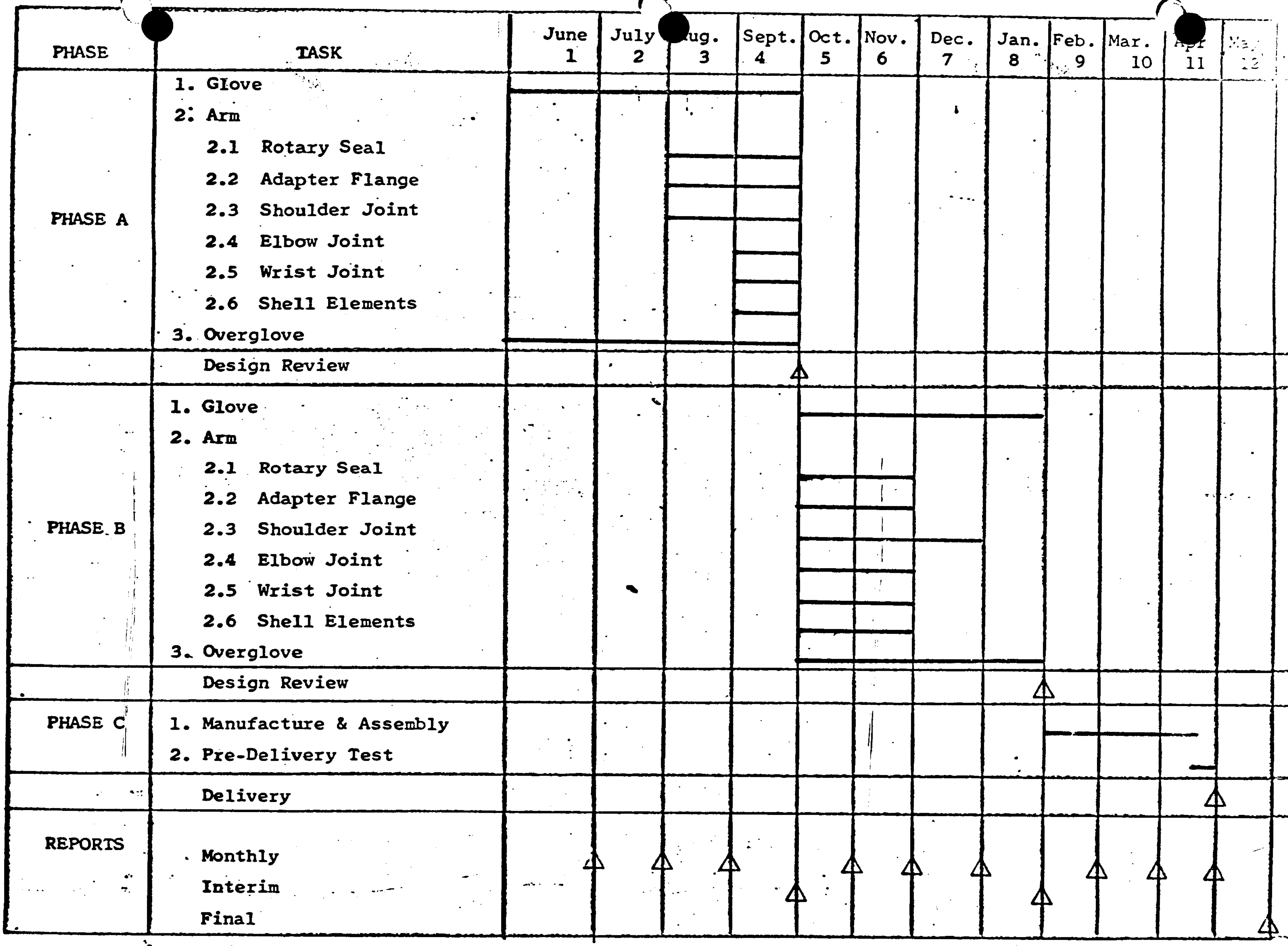


FIGURE 1.- RECOMMENDED REVISED SCHEDULE

PHASE B

1. Glove Development

At the design review marking the culmination of Phase A of the project the first prototype glove was demonstrated at a pressure differential of one full atmosphere in the presence of NASA representatives.

The glove was considered to have performed satisfactorily; however, it was noted that there was scope for improvement in one or two areas.

An intensified redesign effort was made in the area of glove development during Phase B of this program. The pressurizable breadboard model of the glove, demonstrated previously at the Phase A design review, was used as a guide for further development. Mobility models of various designs for the glove were constructed to determine whether the required mobility could be achieved. Special attention was given to increasing thumb mobility. One design that was investigated included two rotary seals at the thumb whose planes were orientated so as to permit mobility similar to that which is afforded the arm at the upper arm transition. However, a two-axis rolling convolute thumb joint concept demonstrated that this approach was more consistent with the design goals of mobility, ease of fabrication, and cost. A new mobility model was therefore made which incorporated the following improvements over that of the previously designed glove with rolling convolute thumb joints:

1. The thumb joint was redesigned to include two rolling convolutes for mobility. Additionally, the thumb joint was repositioned on the palmar shell.

2. The first metacarpal joint was reconfigured slightly and also enlarged. The hinge/pivot system for the first metacarpal joint was designed to include an offset configuration to avoid obstruction of the rolling convolute. This design was subsequently incorporated into the thumb joint.

3. The palmar shell element was modified to fit the hand more closely.

Detail drawings of the component parts of the glove were completed in December. Mandrel fabrication was halted when problems were experienced in shaping the stainless steel sheet by the conventional method of hand hammering. The tendency of the stainless steel to work harden rapidly, and the smallness of the radii in the parts led to the decision to use alternative methods. For the metacarpal ring a drawing die was designed.

Two methods of fabrication were under consideration for machining the large thumb ring. The first method was a 3-D milling process, whereby the ring is machined from one piece of stock; the other was to machine the ring in two pieces and then weld the parts together.

Both methods of thumb ring fabrication progressed concurrently until such time it was assured that the ring could be machined successfully using the 3-D milling process. The use of the other method of fabrication was discontinued. The design, in which the emphasis was on optimum mobility, has however, proved to be difficult to manufacture.

The small thumb ring was made by an end-mill process. The aluminum palmar shells were fabricated on epoxy mandrels.

The required parts for two complete glove/wrist assemblies were completed as illustrated in Figure 2 and attached to the two prototype arms. The right hand glove/wrist assembly was tested in a vacuum chamber at one-atmosphere of pressure, the results of which demonstrated that the glove has satisfactory mobility and structural integrity. The test data are found in Appendix A.

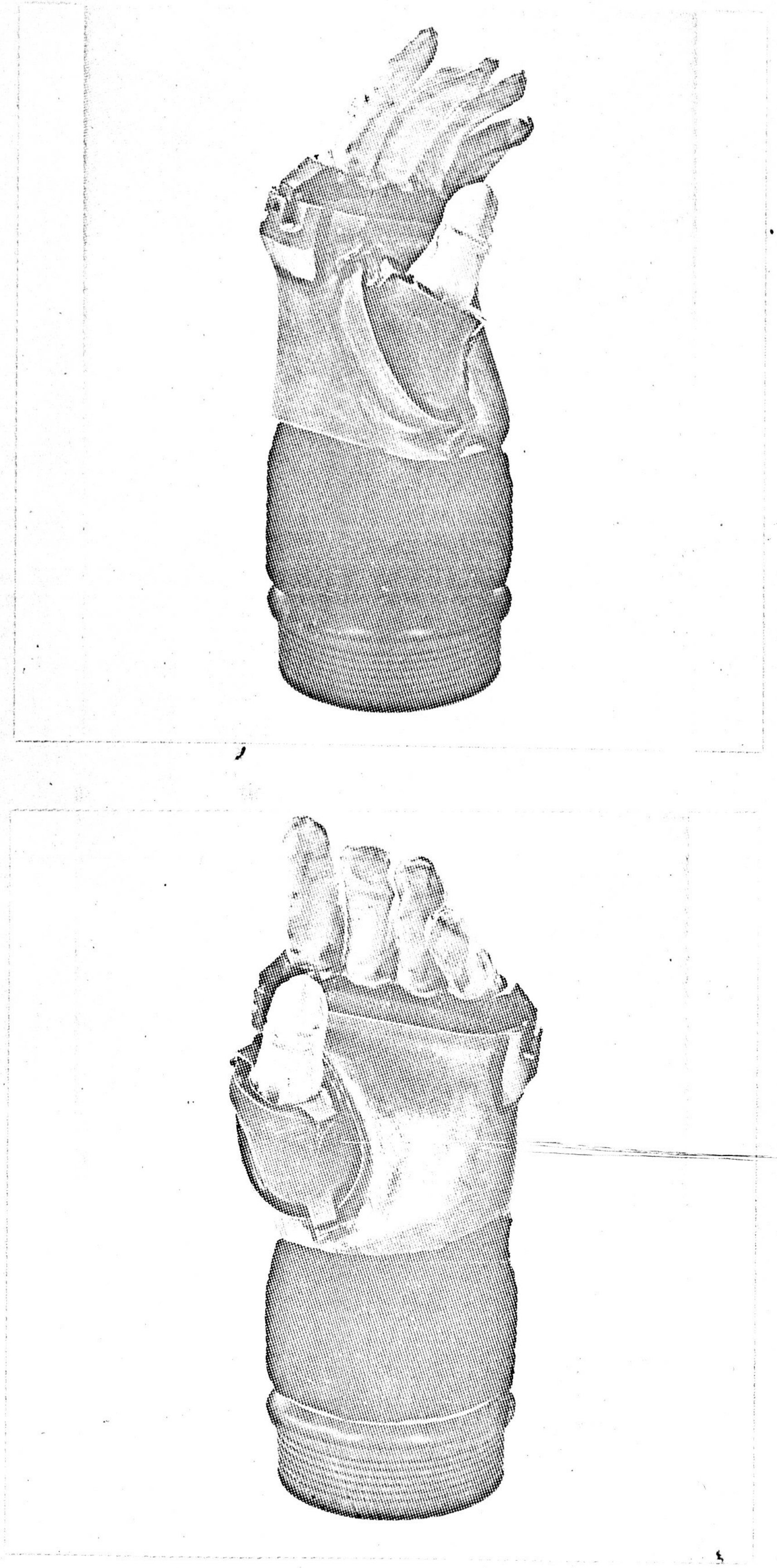


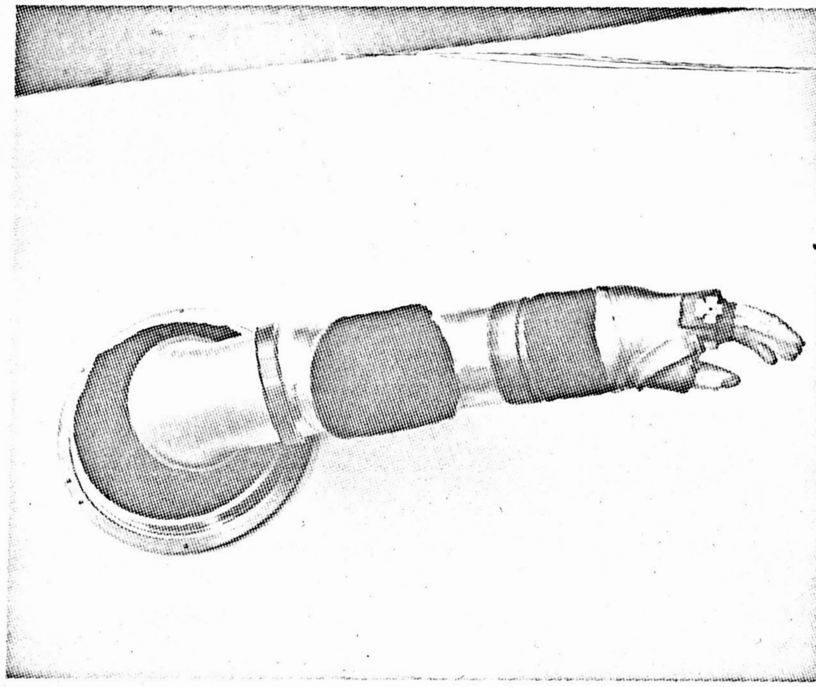
Figure 2 LRL Glove/Wrist Assembly

2. Arm Joints and Shell Elements

All components for two LRL arms were completed and assembled as illustrated in Figure 3. The LRL arms differ from the RX-3 design principally in their structural characteristics. They are designed for substantially increased strength because the contract requirements are that there will be no yield at 20 psi or structural failure at 25 psi. Mobility range is identical with that of the RX-3.

The existing RX-3 hinges for the elbow joint and wrist joint were not designed for operation in a one atmosphere environment, consequently, a redesign effort was required. The new hinges were made in a double clevis configuration from 7075-T6 aluminum. The pivot pins were made from 17-4 H900 stainless steel. A structural analysis of the hinge design has shown this change to be acceptable for loads encountered while operating in a one-atmosphere environment. Additionally, the roll-pin type of pivot retainers were replaced by a simpler and more effective metal clip.

The shoulder joint rings were machined from 17-4 PH condition A stainless steel forgings that were then heat treated to



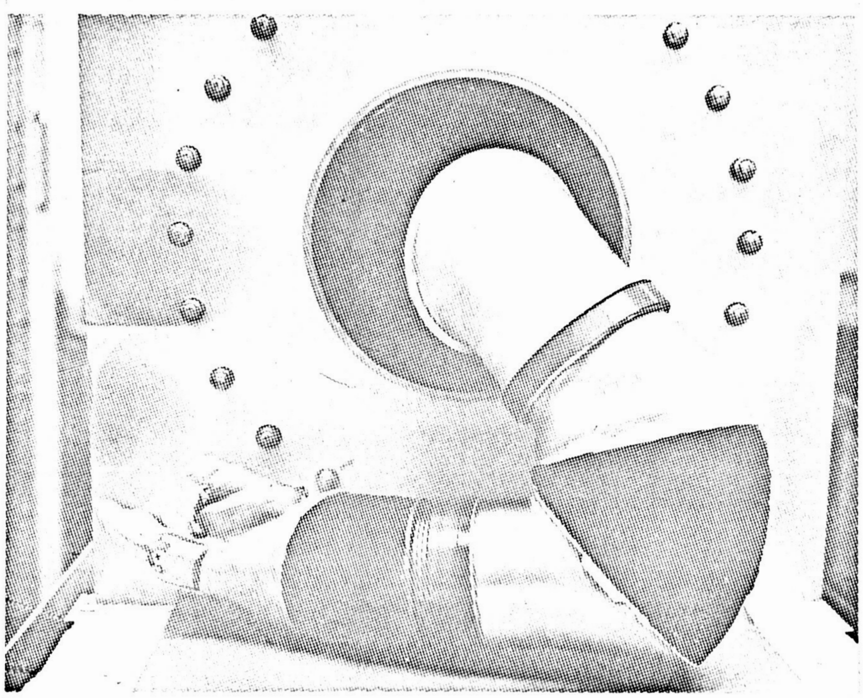


Figure 3 LRL Army Assembly

a H900 condition. The pivots are stainless steel rod end bearings.

No changes were made in the design of the rotary seals, which remain identical with those used on the RX-3 pressure suit, with the exception that vespel balls were substituted for the Lexan balls. This was due to the increase in the differential pressure requirement from 3.7 psia to 14.7 psia.

Shell elements are essentially unchanged from the RX-3 design.

A test fixture was designed and constructed to pressure test both the arm assembly and/or the overglove. This fixture simulates the LRL chamber inner and outer walls.

An assembled arm was successfully demonstrated at one atmosphere of pressure to NASA personnel at the Phase B design review meeting held at Litton on January 30, 1967.

Additionally, the left arm was successfully tested at a proof pressure of 20 psig. The test data are found in Appendix A.

The two LRL arm systems are expected to be sent to NASA in February.

3. Overglove Development

At the design review that was held at the conclusion of Phase A of the program, permission was granted to use Viton A for the exposed surface of the overglove with the stipulation that the work glove itself be made of either FEP teflon or knitted stainless steel cloth.

It was decided that the hand segment of the Viton A overglove could be made best by using a dip forming technique. The DuPont Fabrics Division was contacted for pertinent information. The recommended dipping solutions were ordered. It was decided that the completed hand segment would be bonded to the main sleeve of the overglove which would be constructed from Viton-A impregnated nylon fabric.

The size of the main sleeve of the overglove was determined from a mockup LRL inner arm mounted in a simulated LRL chamber. Inexpensive fabric was used for development of the pattern.

Because the final size of the overlgove and work glove depended on the final size of the pressure glove, the fiberglass mobility model of the glove assembly was used as a pattern to construct a left-hand master mandrel for the overglove (see Figure

4). This mandrel was made of epoxy.

In order to exactly reproduce the features of the left hand master mandrel in both left and right hand forms, a multiple spindle carver was used. The resulting wooden forms were used to make molds for the final left and right hand dipping tools. An experimental dip was made from the original epoxy master mandrel to prove the design. In the event that any modifications were indicated, it would be a simple matter to recontour the wooden forms.

Drawings were completed for assembly jigs to form the upper arm end of the overglove and for bonding the dipped portion to the impregnated fabric portion. These jigs were completed in January.

Tests were conducted to determine the best method of bonding the dipped glove to the impregnated fabric sleeve. The test data are to be found in Appendix A. Test results indicated that a one-inch lap joint bonded with Caram V641D Viton adhesive would meet the requirement.

Completion of the overglove was delayed due to the necessity of recontouring the dipping mandrels slightly and as a result the overgloves were not submitted for inspection at the design

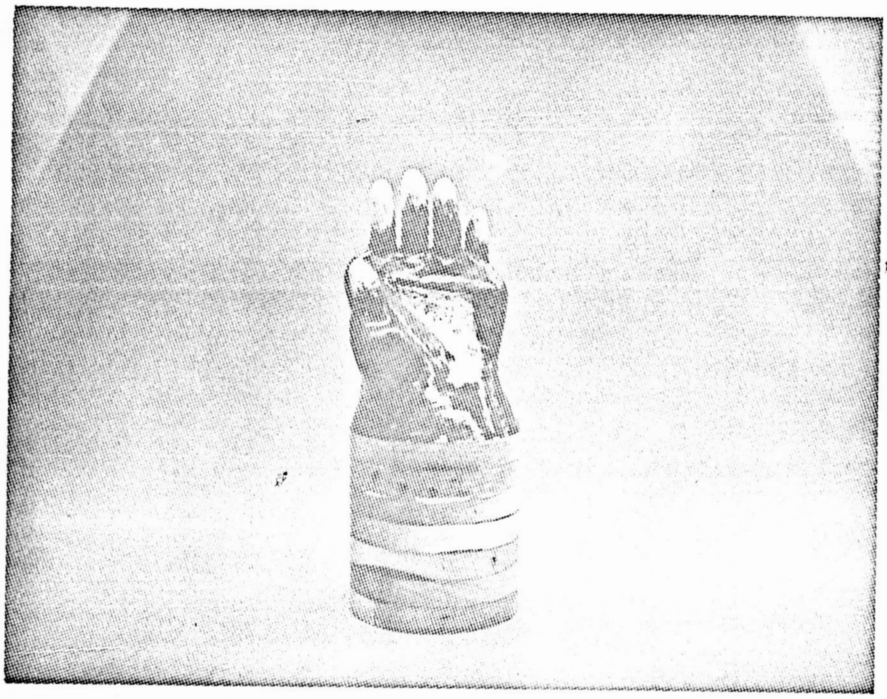


Figure 4   Left-hand Master Mandrel for Overglove

review. The overgloves will be completed early in March.

4. Work Glove

The prerequisite that stainless steel and teflon alone would be permitted to contact the sample or interior of the vacuum system was relaxed to allow the use of Viton A for the overglove. However, the work glove itself, encasing the hand and wrist, was still required to be made of FEP teflon or stainless steel knitted fabric. A research effort was consequently directed towards the development of a wrist length glove of these materials.

Parallel developmental programs were conducted employing both stainless steel knit and dip-formed teflon for subsequent use in the glove. The results are discussed below.

1. Teflon Work Glove

The heat sealing of teflon film, accomplished during Phase A, was unsatisfactory because of the nonuniform character of the weld. The problem of forming teflon into contoured shapes remains a difficult one; however, the fact that the non-permeability requirement no longer applies to the work glove itself prompted investigation into the possible dip-forming of teflon.

The DuPont Dispersions regional office in Burlingame, California, was approached for technical assistance in the development of a work glove using teflon dip-forming techniques.

It was found that no technique had yet been developed that allows satisfactory removal of the membrane from the mandrel. Nevertheless, the effort admitted of feasibility under the proper conditions. Of major importance is the necessity for a very high degree of smoothness on the surface of the dipping mandrel.

A chrome plated mandrel was fabricated for experimentation in dip-forming teflon. A teflon dispersion solution was received from DuPont, and several dips were made.

Experiments showed that a dip-formed teflon work glove is not feasible at this time (see Figure 5).

It was found that the teflon dispersion would not sinter properly. Furthermore, the teflon could not be successfully removed from the mandrels.

2. Stainless Steel Knit Work Glove

The use of stainless steel knit or weave had been

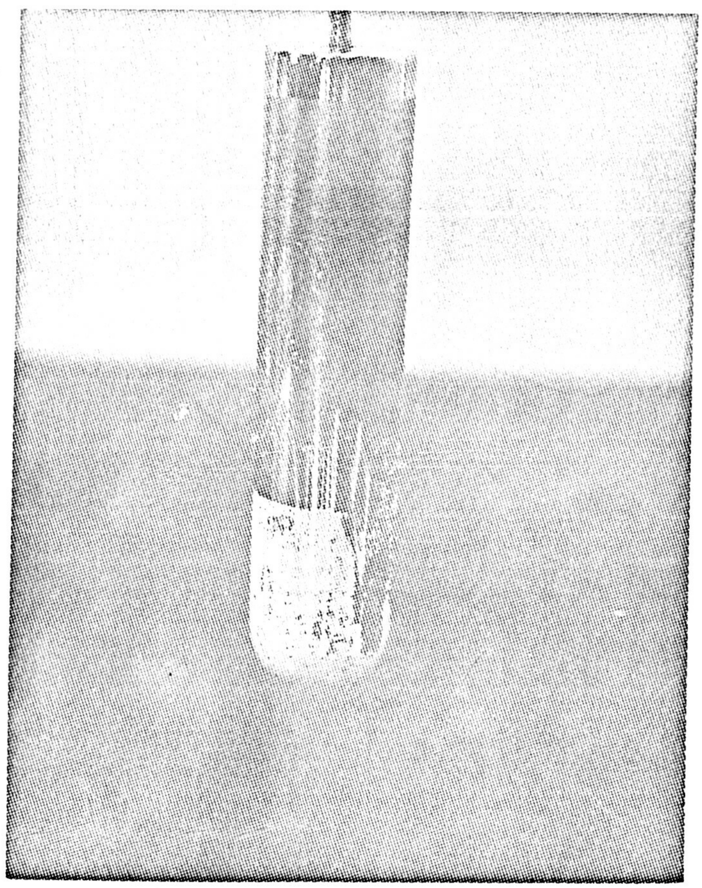


Figure 5 Mandrel with dip-formed teflon

seriously considered early in Phase A of the program. At that time its proposed use was for the whole overglove, and entailed impregnating the stainless steel mesh with teflon to provide pressure integrity.

Fabric Research Laboratories, Inc. of Dedham, Massachusetts felt that it would be possible to knit a glove from stainless steel monofilament fibers, but because of pin holes in the teflon impregnation impermeability was hard to achieve and the matter was not pursued.

With the changed requirement that rendered the work glove independent of the pressure barrier, investigations into stainless steel fabric were reopened.

A sample cloth woven from MF-Al-12/90/7Z stainless steel yarn (manufactured by the Brunswick Corporation) was examined by Litton. It was considered satisfactory for an abrasion resistant work glove.

RFQ's were issued to several companies whose competence in the knitting field is recognized. The response from Technical Wire Products, Inc., Cranford, New Jersey seemed particularly promising. They proposed to fabricate wrist length gloves from knitted stainless steel fabric. The fabric has the texture of soft cotton, is abrasion resistant, flexible, and can be worked by the usual cut-and-sew techniques.

A sample knit stainless steel cloth from the Technical Wire Products Company indicated that the cloth would be suitable for making the work glove. Litton intends to place a purchase order for a pair of gloves as soon as a glove pattern is devised. The glove pattern is expected to be completed early in February.

Prepared by *R. J. Homeyer*

Approved by *G. R. Calkins*

APPENDIX A

LRL TEST REPORT NO. 1

Test: LRL Glove/Wrist Assembly

Type: Mobility and General Evaluation

Date: January 30, 1967

Procedure Reference: LRL Test Specification No. 1

Results

The glove metacarpal joint exhibited good mobility and very low resistive torques. The two thumb joints performed quite well, though it should be noted that neither thumb convolutes deployed in an optimum constant volume manner.

In general, the glove affords good mobility at one atmosphere pressure differential, while requiring operator effort well within acceptable limits (see Figure 6).

Conclusions

The LRL prototype glove/wrist assembly, as demonstrated at the Phase B design review meeting, proved to be quite satisfactory for use in a one-atmosphere pressure differential environment.

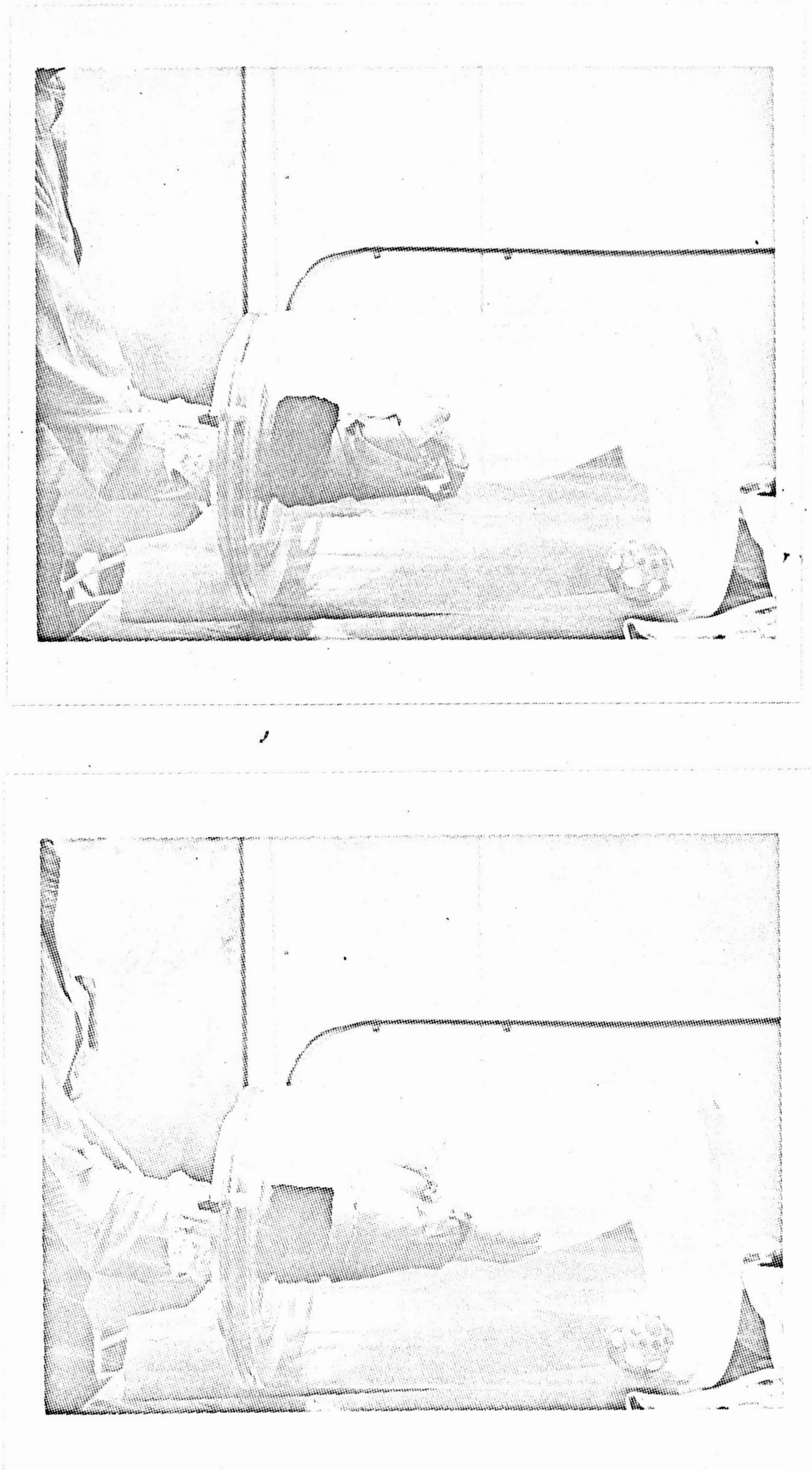


Figure 6 - LRL Wrist/Glove Assembly at One Atmosphere Pressure Differential

LRL TEST REPORT NO. 2

Test: LRL Inner Arm, Complete

Type: Leak Rate

Date: January 29, 1967

Procedure Reference: LRL Test Specification No. 2

Results

Following the 20 psi structural test, the leak rate was measured at 21 cc/min at 14.7 psi using flow meters calibrated to read in scc at 5 psi. This converts to $21 \times \frac{29.4}{19.7} = 32$ scc/min at 14.7 psi when corrected for the increased pressure.

This is well within the contractual limit of 50 scc/min at 14.7 psi.

Conclusions

The LRL arm, when properly assembled and tested, exhibits a leak of less than 50 scc/min at full operating pressure.

LRL TEST REPORT NO. 3

Test: LRL Inner Arm, Complete

Type: Structural

Date: January 29, 1967

Procedure Reference: LRL Test Specification No. 3

Results

The complete inner arm successfully withstood 20 psi differential pressure for 15 minutes. The wrist abduction/adduction ring was later observed to have taken a slight permanent set, indicating that it had been stressed in bending slightly beyond its yield point. Measurements showed that, while this ring is nominally 0.06 inch 6061-T6 aluminum, the edges became thinned to approximately 0.035 inches in the draw-forming process.

This ring (drawing 239169-1) is being changed to 17-7 TH1050 0.050 inch stainless steel, which has a yield strength of 150,000 psi as opposed to 35,000 psi for the present 6061-T6 aluminum. It will be retrofitted into each prototype arm before delivery to NASA.

Conclusions

The LRL inner arm, with retrofitted wrist abduction/adduction ring, is structurally sound to at least 20 psi differential pressure.

TEST REPORT

TEST: LRL Overglove Bond Samples

TYPE: Structural, Tension

DATE: December 27, 1966

PLACE: Litton Space Sciences Laboratories

Procedure

DuPont 88-002 Viton coated Nomex (nylon) cloth was cut into 1 inch strips. These strips were bonded together using either DuPont 5159 or Caram V641D Viton adhesive. After curing, the test strips were pulled on a tensile testing machine equipped with fabric pulling attachments.

Results

In general, the first batch of samples (see Table I) failed at a lower load than the second batch. This was considered to be due to too short a cure of the first samples.

The DuPont adhesive seemed to promote delamination, exposing the Nomex fabric upon failure.

Conclusions

A 1 inch lap bond using Caram V641D Viton adhesive gives a bond that is as strong as or stronger than the parent fabric.

TABLE I. ONE INCH WIDTH VITON/NOMEX FABRIC TEST STRIPS

BOND TYPE	BOND AGENT	FAILURE LOAD	FAILURE TYPE
1/2" Lap*	Caram V641D	70 lb	Bond Failed
3/4" Lap*	Caram V641D	60 lb	Bond Failed, broke @ 125 lb.
3/4" Lap	Caram V641D	115 lb	Bond Failed
3/4" Lap	DuPont 5159	115 lb	Bond Failed, delamination occurred
1" Lap*	Caram V641D	85 lb	Bond Failed, broke @ 115 lb
1" Lap	Caram V641D	125 lb	Parent Fabric Failed
1" Lap	DuPont 5159	90 lb	Bond Failed, delamination occurred
1 1/4" Lap*	Caram V641D	110 lb	Bond Failed, broke @ 125 lb.
1 1/4" Lap	Caram V641D	125 lb	Parent Fabric Failed
1" Beaded Lap	Caram V641D	135 lb	Bond Failed

* "Short" cure of bond